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PROGRESS REPORT ON RESEARCH AND RELATED SERVICES APPLICABLE TO RICE

Including Work in United States Department of Agriculture and Cooperative Studies with the State Experiment Stations

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Prepared for Use in Connection with the
December 1956 Meeting of the
RICE Research and Marketing Advisory Committee

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This Progress Report is a "tool" for: (1) Advisory committee use in formulation of recommendations in regard to present and future programs; (2) Administrative use in program development, coordination and evaluation. The material in this Report is not for publication. The Report includes research findings that have already been released. When mention is made of these findings, the publication containing the public release is also cited. Any reference to published findings should mention the publication in which the release was made, not this Progress Report. Included also are many tentative findings that have not been sufficiently tested for public release. When results are ready for release, the information will be made available through established channels.

For the reasons given, copies of the Report are available only to research administrators and workers directly concerned with the development and conduct of the program and to advisory committee members. Those receiving it are asked to observe strictly the limitations: "Administratively Confidential -- (Not to be Quoted or Copied)."

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C.
December 1956

(RICE)

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FUNCTIONS OF ADVISORY COMMITTEES

The Rice Research & Marketing Advisory Committee is one of a number of committees authorized by Congress in 1946 to advise the Department of Agriculture with respect to specific research and service work.

The committees have been asked to consider all of the research and marketing service work of the Department in their respective fields. This is in recognition of the value the Department places upon the advice and counsel received and is in accord with suggestions of Congressional committee members who are directly concerned with the work.

The committees are performing an important function in advising with respect to the development of the Department's research and marketing service programs. However, it is recognized by members of Congress, committee members, and the Department that the implementing and administering of these programs are the responsibility of the Department.

The functions of the advisory committeemen include:

1. Acquainting themselves with the problems of consumers, producers, all segments of the industry and of other groups, and presenting them for committee consideration.

2. Reviewing and evaluating the current research and marketing service programs of the Department, including work under way at Federal laboratories and field stations.

3. Recommending adjustments in the Department's program, including priorities for new work and expansion of work under way.

4. Developing a better understanding of the nature and value of the agricultural research program, explaining it to interested persons, groups and organizations and encouraging the wider and more rapid application of the findings of research.

COOPERATION

Much of the research on rice covered in this report is conduced in cooperation between agencies of the United States Department of Agriculture and the State Experiment Stations. The studies find their origin in problems of producers, processors, distributors and consumers, and representatives of these groups frequently participate in the cooperation. Cooperative programs are jointly planned and conducted in a manner to make full use of the personnel and resources of each participating group with the minimum of duplicative effort. The results of cooperative research are jointly prepared in the form of uniform recommendations.

USDA AGENCY ABBREVIATIONS

ARS - Agricultural Research Service
- AE - Agricultural Engineering Research Branch
- APH - Animal and Poultry Husbandry Research Branch
- DH - Dairy Husbandry Research Branch
- ENT - Entomology Research Branch
- EU - Eastern Utilization Research Branch
- FC - Field Crops Research Branch
- HHE - Household Economics Research Branch
- HN - Human Nutrition Research Branch
- LRP - Livestock Regulatory Program
- NU - Northern Utilization Research Branch
- PPC - Plant Pest Control Branch
- SES - State Experiment Stations
- PE - Production Economics Research Branch
- SU - Southern Utilization Research Branch
- SWC - Soil and Water Conservation Research Branch
- WU - Western Utilization Research Branch

AMS - Agricultural Marketing Service
- AEC - Agricultural Economics Division
- AES - Agricultural Estimates Division
- MR - Marketing Research Division
  - MOC - Marketing Organization and Costs Branch
  - TF - Transportation and Facilities Branch
  - BS - Biological Sciences Branch
  - MD - Marketing Development Branch
  - FRS - Freight Rate Service Branch
  - GR - Grain Division

LO-- Liaison Office, Commissioner of Agriculture

ACPS - Agricultural Conservation Program Service

CSS - Commodity Stabilization Service

FAS - Foreign Agricultural Service

FCS - Farmer Cooperative Service

FES - Federal Extension Service

REA - Rural Electrification Administration

SCS - Soil Conservation Service

FS - Forest Service

I

PROGRESS REPORT FOR RICE RESEARCH AND MARKETING ADVISORY COMMITTEE

I. PRODUCTION RESEARCH

A. Breeding and Physiology

1. Breeding

FC-ARS

Emphasis is being placed on breeding rice varieties that produce high milling yields, and have the desired cooking and processing characteristics. Strains of all grain types are being selected to meet these requirements that also have other desirable characteristics such as seedling vigor, salt and alkali tolerance, stiff straw, uniform maturity, smooth hulls and the characteristics needed to be suitable for the combine-drier method of harvest. The development of medium- and long-grain varieties for the South and short-grain varieties for California is being emphasized. However, some work is being done to develop all types for each area. Varieties and selections from all stations are being tested in the laboratory at Beaumont, Texas, to determine milling quality and cooking characteristics.

Progress is being made in the program to develop early-maturing long-grain types that have kernel characteristics like Rexoro or Bluebonnet combined with the vigor and other desirable plant characteristics of Century Patna. Progeny of the cross Bluebonnet x Century Patna are in the sixth generation and of the crosses Rexoro x Century Patna and Texas Patna x Century Patna are in the third generation. Many of these lines mature early and have desirable grain characteristics. This phase of the breeding studies is being emphasized as there is an urgent need for a variety of this type. Much work is being done to develop medium-grain varieties which meet the requirements outlined above. Zenith, the leading medium-grain variety, lacks many of the characteristics desired, although it produces good grain yield and it is widely accepted to the trade. This variety as well as Magnolia, Nato and others is being used as parent stocks. Medium-grain selections that have stiff straw, smooth hulls and other desirable characteristics are being tested.

Short-grain varieties are most important in California. None of the varieties now grown commercially is adapted for growing where cold water is used for irrigation. The areas where the water is cold are expanding so this problem will become more important. Varieties that tolerate cold water are available, but these varieties have undesirable characteristics so are not suited for growing in California. It is imperative that this hardy characteristic is transferred to our commercial varieties. Hardy varieties have been crossed with commercial varieties, and a method for testing the progeny of these crosses

has been developed. These studies are being conducted in such a manner that the other desirable characteristics will be incorporated in these new types.

The short-grain varieties that are grown in California are not adapted in the Southern area. Many selections now are available that have smooth hulls as well as stiffer straw and more disease resistance than the California varieties.

Quality evaluation studies have made much progress during the past year. The starch-iodine-blue and the cooking-soaking methods have been perfected for testing and cooking characteristics of selections. Only small samples are needed for these methods and positive values are obtained that are correlated with the manner in which varieties react under cooking and processing treatment. Thus, these methods can be used to test hybrid plants and breeding lines. Many breeding lines have been tested in these studies to develop high quality varieties. Other tests such as the eosin dye method, water absorption and alkali digestion method have been studied to determine whether or not they can be used. None of these is being used at this time as the first two methods are not applicable and the latter method needs further study. The rice grain is composed largely of starch so the work of quality evaluation in rice has been confined largely to a study of this fraction of the grain. The other components of the grain may play an important part in the way rice reacts under cooking treatment.

The milling quality was determined for all varieties in all Uniform Yield Nurseries in the Quality Laboratory at Beaumont. A report giving milling quality as well as grain yield was compiled and sent to all cooperators.

A good knowledge of rice genetics and cytology is essential for a sound breeding program. The mode of inheritance of many characters in rice has been determined but this has been more or less a "by-product" of the more urgent job of developing varieties to take care of current needs. With a few exceptions, no work on rice cytology has been done in this country. A study of the cytology of rice was initiated during the past year in the Agronomy Department at Louisiana State University in cooperation with the Field Crops Research Branch. One graduate student works on this project. A report of this work explains the situation that obtains when widely different varieties are crossed and the F_1 plants are partly sterile. This study serves to illustrate the large amount of worth-while information that can be obtained from critical studies in the field of cytology and genetics.

Irradiation as a tool in breeding rice has been studied in Louisiana and Texas during the past 3 years. A strain that has short, stiff straw was obtained from Century Patna 231. It has short internodes at the base of the culm, although the peduncle, panicle and grains are not reduced in length. This strain will be used to develop varieties with good straw.

Foundation seed stocks of all recommended rice varieties were maintained and made available to seed growers. Each station produced seed of each variety developed at that station and, in some cases, seed of other varieties recommended in that State. The production and distribution of high quality foundation seed has been a big contribution to the improvement of the quality of the rice crop in the United States.

Rice breeding experiments will be continued along the lines now being followed, with increased emphasis on fundamental studies in cytogenetics. Attempts will be made to devise methods to evaluate cooking and processing characteristics. All breeding lines and varieties can be tested for quality characteristics to insure that new varieties meet all requirements of the trade. Breeding experiments to develop varieties resistant to blast (Piricularia oryzae) will be initiated, since this disease is becoming more prevalent in the Southern area. Experiments to develop varieties resistant to other diseases should be continued. Breeding experiments to develop superior smooth-hull medium-grain and high quality, early-maturing long-grain varieties for the South; hardy varieties for California, and to evaluate and to classify all varieties from domestic and foreign sources will be continued. Irradiation experiments will be continued in order to explore the possibilities in this field more fully.

2. Seed Storage Facility HC-ARS

Funds for the construction of a National Seed Storage Facility became available July 1, 1956. The Horticultural Crops Branch, ARS, through its Plant Introduction Section, has the responsibility for assistance in planning the building, selection of the staff, and future, over-all administration of the work performed at the Seed Storage.

A site for the building has been selected on the campus of the Colorado Agricultural and Mechanical College at Fort Collins, Colorado, and transfer of the land to the United States government is under way. This will include storage for seed of rice varieties from the World Collection.

Tentative plans for construction include: (1) storage rooms with controlled temperatures and humidities; (2) a seed cleaning room equipped to handle lots of seed regrown and harvested under contract by qualified workers experienced in the culture of the particular crop plant; (3) a seed laboratory which will provide facilities for periodic checks on the viability of seed held in the storage as well as research in seed physiology for the purpose of determining optimum conditions for seed storage, and (4) office, general storage and library space for workers.

3. Physiology FC-ARS

The physiology of the rice plant is being studied in cooperation with the Arkansas Agricultural Experiment Station at Stuttgart. These experiments include studies of the cause of straighthead, alkali toxicity,

symptons caused by a deficiency of each nutrient element, the general development of the rice plant and control of algae. Straighthead was studied in the greenhouse, using several soil types, irrigation treatments and fertilizer applications. Results indicated that depth of irrigation water and the addition of organic matter at different rates had no effect on the severity of straighthead although typical symptoms were produced by the addition of 80 ppm of As_2O_3 to the soil. The addition of minor elements in the chelated form to alkaline soil in the field and in the greenhouse did not result in better growth of rice plants of the variety Bluebonnet 50. The development of Zenith and Bluebonnet was studied in the field, using various methods of irrigation and seeding. Plants were shortest with an 8-inch flood and tallest when the soil was kept puddled. Plants grown as "upland" were latest in maturing. No differences in numbers of tillers resulted from different irrigation treatments. The symptoms produced by a deficiency of each plant food element was observed by growing plants in nutrient cultures. The results of these studies will give basic information that is essential to the solution of nutritional problems occurring under field conditions. Delrad, an organic material that shows promise as an algacide, was not toxic to young rice plants at practical rates of application.

The studies on deficiency symptoms caused by the various elements and on development of the rice plant should be completed in about 2 years. The knowledge and experience gained from these studies will then be applied to a more intensive study of physiological diseases and abnormal nutritional situations occurring under field conditions. The experiments on control of algae can be reduced as fairly good control can be obtained by following recommendations based on results of work accomplished during the last 3 years.

4. Rotations and Cultural Practices FC-ARS

Most of the rice farms in the Gulf Coast area of Texas and Louisiana include livestock as a part of their farm operation. Rice and cattle production on improved pastures is being compared under four different rice-pasture rotation systems in cooperation with the Texas Agricultural Experiment Station and the Texas Rice Improvement Association. Improved pastures between rice crops has increased rice yields ten to thirty percent, while fertilizer costs have been reduced $5.00 to $15.00 per acre. About 100 pounds of beef is produced per acre annually on first year improved pastures, and 250 pounds on second year and older pastures. Less than 50 pounds are produced on unimproved pastures. Pastures are established by broadcasting a mixture of Dallis grass and clover seed by airplane on rice stubble from mid-October until mid-November. Thirty to 60 pounds of available P_2O_5 per acre are broadcast in the fall of establishment, and 30 pounds each subsequent fall. Development of these methods has reduced establishment costs fifty to seventy-five percnet. Hard seeded clovers, after one and sometimes two rice crops reestablish without reseeding. This reduces subsequent establishment costs. Pasture land plowed and leveled for rice by November ordinarily becomes well

established to clover, in the winter and will support an animal unit or more per acre during March until time for final preparation for rice seeding. These studies are being continued. The search for better pasture or forage species and varieties from the Plant Introduction Section, A.R. S., continues at Beaumont, Texas. At present three such introductions seem to have unusual promise. An annual ryegrass (Lolium multiflorum P. I. 193145) from Uruguay is more productive in the winter and rust resistant than ryegrasses presently available in the Gulf Coast area. This introduction is being increased for release. An annual sweet Clover (Melilotus alba annua P. I. 200355) is highly productive and matures two months later than Hubam sweet clover. This late maturing annual sweet clover can be grazed as late as June and July when most other winter annual legumes are non-productive. A Persian clover P. I. 180492 from West Pakistan is more productive and later maturing than available commercial Persian clover. The original introduction contained only about 0.5 percent hard seed. Through selection, this hard seed content has been raised 25 to 50 percent in some lines. Another year or two of selection may raise the leve of hard seed sufficient for release of this strain.

Publications:

Changes in Rice Varieties in the United States from 1931 to 1954. C. Roy Adair. Processed Report, pp. 1-2. IRC, Working Party on Rice Breeding. IRC/BP/55/32. Dec. 1955 (Processed.)

Welcome to the Texas Agricultural Experiment Station. L. E. Crane et al. Substation No. 4, Beaumont, Texas. MP-162, p. 1-24. Febr. 1956.

Testing and Breeding Rice Varieties for Resistance to the Straighthead Disease, John G. Atkins, H. M. Beachell and L. E. Crane. Rice Journal 59(6): 36, 38. 1956.

Research on Improved Milling, Processing and Cooking Quality of Rice. H. M. Beachell and J. V. Halick. Rice Journal. 1956.

Rice Uniform Yield and Milling Quality Report. H. M. Beachell and J. V. Halick. Field Crops Res. Br. Proc. Rpt. 333-CC, p. 1-50. Jan. 1956.

The Use of a Starch-Iodine-Blue Test as a Quality Indicator of White Milled Rice. J. V. Halick and K. K. Keneaster. Cereal Chem. (In press.)

Present Status of Rice Genetics. N. E. Jodon. Jour. Agr. Assoc. China. N. S. No. 10: 5-21. June 1955.

Observations on Magnolia and Rexoro Rice Grown from Irradiated Seed. N.E. Jodon. Report at Working Conference on Radiation-Induced Mutations. Brookhaven Nat. Lab. May 1956.

Breeding for Improved Varieties of Rice and Other Cereal Grains. Nelson E. Jodon. Louisiana Agr. Exp. Sta. Ann. Rpt. 1953-54. pp. 241-246. April 1955.

Toro and Sunbonnet - Two New Midseason, Long-grain Rice Varieties Compared. Nelson E. Jodon. Rice Jour. 58(13):8-11. Dec. 1955.

Rice Breeding. N. E. Jodon. La. Agr. Exp. Sta. Ann. Rpt. 1954-55, p. 242. April 1956.

Improving Varieties of Rice and Sorghum. N. E. Jodon. La. Agr. Exp. Sta. Prog. Rpt., 1956.

Genetics of Some Bizarre and Common Characters in Rice. N. E. Jodon. Jour. Hered. (In press.)

Rice Varieties for Arkansas in 1955. T. H. Johnston. Mimeo. Rpt. to County Agents, pp. 1-6. Febr. 1955.

New Varieties for Arkansas Due Soon. T. H. Johnston. Rice Jour. 59(5): 43-44. 1956.

Recent Research in Rice in Relation to Soil Alkalinity and Straighthead. Ark. Farm Res. 1956.

B. Insects, Diseases, Parasites, etc.

1. Diseases FC-ARS

Rice disease investigations have been adjusted to increase the work on parasitic root nematodes. Soil fumigation tests were conducted to determine the effect of these nematodes on the growth and yields of rice. At one location methyl bromide-treated plots produced 831 pounds per acre more rice than untreated plots. Although this treatment is not economically feasible, the results of this experiment demonstrate the yield reduction caused by the parasitic root nematodes.

Seed treatment tests for the control of white tip were conducted in Arkansas and Texas. The nematocide N-244 in its present formulation does not effectively control white tip. However, effective control measures are known and foundation seed can be kept free of white tip nematodes so that practical control of this disease can be maintained. Seed treatment experiments for the control of seedling blight were conducted in Arkansas, Louisiana and Texas. Some of the fungicides gave substantial increases in the percentage of seedling emergence compared to no treatment. This was especially true for early seeding. A seed treatment test conducted in Texas for the control of kernel smut gave inconclusive results as there was very little smut in any of the plots.

Helminthosporium leaf spot was severe on rice grown on station plots and many farm fields in Texas. F_3 progeny of crosses between commercial varieties and a Helminthosporium-resistant line were grown in a disease nursery at Beaumont where good infection was obtained by planting a susceptible variety every third row. Helminthosporium-resistant lines that have other desirable characteristics such as short, Straw, early maturity, vigor and good grain type were recovered. Many varieties and selections from each of the Southern Stations were tested for straighthead resistance in a nursery near Eagle Lake, Texas. The performance of the standard varieties was the same as in previous years, and some of the selections were resistant. The primary sources of resistance in long-grain strains are Fortuna and C. I. 5094. The reaction of varieties and selections to white tip and stem rot was determined by artificially inoculating plants grown on field plots with the causal organism of these diseases. Resistant selections were identified.

Piricularia oryzae was observed in several fields in Louisiana on late sown plants when in the early tillering stage. The disease was noted in fields of high fertility. A trace of this disease also was observed on susceptible varieties in the World Collection on Station plots at Beaumont. Although the reduction in yield was not great, the occurrence of this disease indicates the necessity of having resistant varieties for the southern area because the increased use of rotations and fertilizers creates conditions favorable to Piricularia.

Abnormal plants were observed in a field of Bluebonnet 50 rice growing on the Rice-Pasture Experiment Station. A Fusarium was isolated from several of these abnormal plants. The symptoms suggest the Bakanese disease which is caused by Gibberella fujikuroi.

The rice disease experiments will be continued along the same lines as at present. As time permits, more attention will be devoted to basic research on the fungi which causes disease of rice.

Publications:

Reaction of Rice Varieties to Straighthead. J. G. Atkins, H. M. Beachell, and L. E. Crane. Tex. Agr. Exp. Sta. Prog. Rpt. 1865, pp. 1-2. April 1956.

An outbreak of Piricularia on Rice in 1955. J. G. Atkins. Pl. Dis. Rptr. 40(5): 372-3. 1956

A Preliminary Report on the Response of Rice to Soil Fumigation for the control of Stylet Nematodes, Tylenchorhynchus Martini. J. S. Atkins and Max J. Fielding. Pl. Dis. Rptr. 40(6): 488-489. 1956

2. Rice Field Insects ENT-ARS

Investigations on the control of the rice water weevil in Louisiana showed that dieldrin at .5 lbs. per acre was more effective than heptachlor at 1 lb. or toxaphene at 3 lb. Thimet applied as a seed treatment at 1 lb. per 100 lbs. of seed did not provide control. Although the larvae per linear foot of rice was reduced from 138 in the check to 2 in the plots receiving the dieldrin treatment there was no significant increase in the yield of rice in the treated over the untreated plots.

Studies in Louisiana have indicated that dieldrin, aldrin, toxaphene and heptachlor are effective for the control of the rice stink bug, but additional data are needed on residues at harvesttime before any of these insecticides can be recommended.

A formula was developed to express the loss caused by the rice stink bug and is useful in determining under what conditions it is profitable to treat rice to control this pest.

This work will be continued with special effort directed toward obtaining sufficient residue data so that insecticidal control of the rice stink bug can be recommended.

C. Farm Practices and Equipment

1. Weed Control in Rice FC-ARS

Research studies on the control of weeds in rice are under way in California and Arkansas. The investigations are concerned with evaluations of promising herbicides as agents for controlling weeds selectively in rice under the conditions found in rice culture in these two areas. Special emphasis is being given to developing methods of controlling grass weeds, notably Echinochloa crusgalli, that infest rice fields and to find compounds with less drift hazard than 2,4-D to crops adjacent to rice fields when treating for broadleaf weed control.

In Arkansas, applications of CIPC just prior to the emergence of rice (delayed pre-emergence) or immediately following emergence of rice (early post-emergence) have shown good promise for controlling grass weeds in rice with little or no injury to the crop. Applications of 4 to 8 pounds per acre to rice planted one to 1½ inches deep have given best results. The application of CIPC impregnated in a granular material also showed promise in California for controlling grass in rice.

Several varieties of rice tested in Arkansas for tolerance to an amine salt of 2,4-D have responded similarly. Least injury to the crop occurred when treatments were made during the late tillering or pre-joining stages of rice. An amine salt of 2,4,5-T, which is approximately 8 to 10 times less damaging to cotton than 2,4-D, has satisfactorily controlled coffee, weed, curly indigo, and mud plantain in rice and could be used advantageously for weed control in rice fields near cotton.

Current work is to be expanded in Arkansas on the control of grass weeds in rice by initiating some large tests in cooperation with farmers. Basic studies are planned on the weed seeds infesting rice fields, behavior of the herbicides in rice soils and detailed morphological and physiological studies on the effect of certain herbicides on the rice plant.

2. Basic Research Studies on Submerged Soils SWC-ARS

Results are reported which indicate that the sometimes unfavorable effect of green manure on paddy rice is linked to sulfate sulfur deficiency. A different in manganese availability was the factor primarily responsible for the better growth of rice in paddy than in upland culture. On Brookston silt loam manganese, sulfate, and chelated iron applied to upland rice made the yield equal or superior to that obtained in flooded soil. Such nutrients as boron, zinc, calcium, magnesium, and others apparently are far less critical than are iron and manganese. Other experimental work indicates that the nitrogen feeding ability of rice is very similar under lowland and upland conditions of growth.

Work has been initiated to study the salt tolerance of rice grown on fine-textured soils having limited permeability and relatively high water table. A study is also in progress on the interaction of root temperature and nutrient supply on the mineral nutrition of rice. This work is being continued.

3. Long Chain Polymers to Reduce Evaporation SWC-ARS

Preliminary experiments were made at Stoneville, Mississippi, on the use of long chain alcohols and acids to reduce evaporation from rice paddies. These compounds apparently will not reduce evaporation from water surfaces in the summer when it is hot, and consequently their use in rice paddies is doubtful. A number of other materials are being screened along with certain plastic films for possible use in rice production. This work will be continued.

4. Improved Pastures in Rotation with Rice FC-ARS

Most of the rice farms in the Gulf Coast area of Texas and Louisiana include livestock as a part of their farm operation. Rice and cattle production on improved pastures is being compared under four different rice-pasture rotation systems in cooperation with the Texas Agricultural Experiment Station and the Texas Rice Improvement Association. Improved pastures between rice crops has increased rice yields ten to thirty percent, while fertilizer costs have been reduced $5.00 to $15.00 per acre. About 100 pounds of beef is produced per acre annually on first year improved pastures, and 250 pounds on second year and older pastures. Less than 50 pounds are produced on unimproved pastures. Pastures are established by broadcasting a mixture of Dallis grass and clover seed by airplane on rice stubble from mid-October until mid-November. Thirty to 60 pounds of available P_2O_5 per acre are broadcast in the fall of establishment, and 30 pounds each subsequent fall. Development of these methods has reduced establishment costs fifty to seventy-five percent. Hard seeded clovers, after one and sometimes two rice crops reestablish without reseeding. This reduces subsequent establishment costs. Pasture land plowed and leveled for rice by November ordinarily becomes well established to clover, in the winter and will support an animal unit or more per acre during March until time for final preparation for rice seeding. These studies are being continued.

5. New Forage Introduction Show Promise in the Rice Areas FC-ARS

The search for better pasture or forage species and varieties from the Plant Introduction Section, A.R.S., continues at Beaumont, Texas. At present three such introductions seem to have unusual promise. An annual ryegrass (Lolium multiflorum P. I. 193145) from Uruguay is more productive in the winter and rust resistant than ryegrasses presently available in the Gulf Coast area. This introduction is being increased for release. An annual sweet clover (Melilotus alba annua P. I. 200355) is highly productive and matures two months later than Hubam sweet clover.

This late maturing annual sweet clover can be grazed as late as June and July when most other winter annual legumes are non-productive. A Persian clover P. I. 180492 from West Pakistan is more productive and later maturing than available commercial Persian clover. The original introduction contained only about 0.5 percent hard seed. Through selection, this hard seed content has been raised 25 to 50 percent in some lines. Another year or two of selection may raise the level of hard seed sufficient for release of this strain.

6. Electric Traps for Survey of Rice Insects AE-ARS

Ninety-two electric traps have been installed in 23 States during 1955 and 1956 through the Economic Insect Survey Section, Plant Pest Control Branch and State Entomologists for survey of economic insects. The general purpose of the survey traps is to detect emergence of insects and determine populations as a guide to the iniation of control measures. During 1956 three States reported, through the Economic Insect Survey Report, the emergence of the sugarcane beetle and one reported the sugarcane borer. Both of these insects are known to attack rice. Some 14 insects infesting rice in storage were found in 1952-1953 to be attracted to an electric lamp radiating energy in the near ultraviolet region, the same type of lamp used in the survey traps during 1956. Field tests of traps equipped with three sources of ultraviolet energy in 1954 in Texas indicated that narrow differences in peak radiation may affect the response of different species of insects. Limited work to determine the optimum attractive wave length of electric radiation to individual species of insects is being conducted at the Texas Station and will be continued.

Work is being continued on possible destruction of insects in stored grain in Nebraska on use of radio-frequency and cathode-ray radiation. Determination of lethal energy requirements is being made in a basic study.

7. Storage and Drying of Rough Rice AE-ARS

Analysis was completed on data previously collected on the relation of germination and milling of rice to temperature, humidity, and velocity of air used for drying laboratory samples. The least loss in milling occurred at saturation deficits of 1.0 to 2.0 inches Hg. throughout the range of drying temperatures. (Saturation deficit is a term sometimes used to describe drying power of the air, and includes the effects of both high temperature and low humidity). On the other hand, germination losses are associated directly with high temperatures and high initial moisture content, the humidity of the air having little effect. No active field work specifically on rice is under way.

Work with other grains indicates that for each grain and each combination of atmospheric conditions there is a minimum rate of air flow below which spoilage can be expected when drying with unheated air. New

methods of measuring grain moisture during drying of oats and corn show that delay in completion of drying results from using air ducts with space between rather than continuous air entry through a perforated floor. Undoubtedly similar results occur in drying rice. Work with other grains will be continued.

Publications:

Effect of Artificial Drying on the Yield of Head Rice and the Germination of Rice by J. L. Schmidt and Emil H. Jebe. Submitted to Agricultural Engineering for publication.

Second paper--same title as above, briefer, more popular discussion submitted to Rice Journal for publication.

D. Economics of Production

1. Systems of Rice Farming in Arkansas PE-ARS

The reduction in the acreage of rice during the last two years emphasizes the need for the inclusion of other enterprises in rice farming systems in order to more profitably use all of the resources on rice farms. A study is underway in Arkansas to provide information and analyses that will be of assistance to individual farmers in determining the most profitable systems of rice farming. Cost and returns data are being obtained for various supplemental enterprises. Special emphasis is being given to irrigated crops and pasture and to the effects of different soil and water resource situations on the choice of enterprises and on the efficiency of rice production. Data are being assembled and analyzed to determine the relative returns from long, medium and short grain varieties of rice under different production situations. These economic studies will be continued.

2. Acreage Diversions PE-ARS

As requested by the 84th Congress a special study was made in 1955 of acreage diversions in 1954 and 1955 crops. Farmers in selected corn, wheat, cotton and rice areas were interviewed to ascertain some of the effects of the allotment programs. A sample of farms in Louisiana were chosen for the rice study. Farmers in the sample participated almost 100 percent in the acreage allotment program. About one-fifth of the farmers overplanted their allotment, but all except one farmer indicated they intended to get into compliance. The acreage of rice for harvest in 1955 was about 18 percent less than the acreage planted in 1954, when tere was no allotments. Only about 15 percent of the land diverted from rice was planted to other crops, the other 85 percent remained idle or was grazed by beef cattle. Farmers tended to improve their cultural practices in an effort to increase yields. The amount of fertilizer used per acre of rice was almost 10 percent higher in 1955 than in 1954. The number of beef cattle were up slightly. Rice yields per acre were about 10 percent higher in 1955 than in 1954. A report presenting the results of the acreage diversion studies will be released in the near future.

II. UTILIZATION AND CONSUMER USE RESEARCH

A. Consumer Use Research

1. Predetermining the cooking Quality of Rice HN-FC-ARS

The cooking quality of twenty-six varieties of rice was evaluated by quantitative measurements of five physical and chemical characteristics which seemed to indicate differences among rice varieties and by panel evaluation of color, cohesiveness, off-flavor, and degree of doneness. Measurements were made to determine the water uptake ratio (weight of cooked rice divided by weight of the raw rice), the volume of cooked rice, iodine-starch values, pH and total solids of the residual cooking liquid.

Seventy-four lots representing 1953, 1954, and 1955 crops of rice of the three grain types -- long, medium and short -- were included in the tests. Most of the rices were grown in Texas, but a few were samples of California, Louisiana and Arkansas crops.

Grain length appeared to be an influencing factor in water absorption of rice, in that most of the long-grain varieties seemed to absorb more water than either of the other two grain-types. Samples that had high water uptake ratios also tended to have the largest volumes of cooked rice.

The total solids and starch contents of the residual cooking liquids as well as the pH values seemed to be independent of grain type, although significant differences among varieties were noted. The residual liquids from many lots of Rexoro long-grain rice had high starch contents, but those of the California grown rices of Calrose, Colusa, and Caloro contained the most total solid material. Most of the residual liquids had total solids contents ranging between 0.70 and 0.90 grams.

Most of the residual liquids had mean pH values between 6.30 and 6.96. However, Texas Patna rice grown on sandy loam soil in Texas in 1954 had a mean pH of 7.78 (the only alkaline liquid), while Texas Patna grown the same year on Beaumont clay soil had the lowest pH, 6.30.

Differences in color, cohesiveness and off-flavor were noted among the rice samples. Variations among lots of rice in color and cohesiveness were attributed to variety and/or to place of growth. Age and condition of the raw rice sample was apparently the influencing factor as to the cause of off-flavor in cooked rice.

Results of the alkali test, applied in March and again in September 1956 to 81 lots representing 25 varieties, showed that the optimum concentration of KOH for a differential reaction under existing conditions was 1.70 percent. Differences in reaction to the alkali test paralleled somewhat differences in cooking quality as measured by the panel and the physical and chemical tests described above. Most of the long-grain varieties underwent moderate dispersal of the kernels,

but Century Patna 231 underwent practically no dispersal, and the Toro and Rexark varieties underwent almost complete dispersal. The medium-grain varieties underwent nearly complete dispersal except for one, Early Prolific, which usually remained undispersed. The short-grain rices tended toward nearly complete dispersal. Microscopic examination of the dispersed starch helped to clarify and confirm the gross observation. The varieties differed as to the manner in which starch granules disintegrated, completeness of their breakdown or hydrolysis, and pattern or configuration assumed by the disintegrated or hydrolyzed starch. A manuscript discussing results of the alkali test is in preparation.

Serial sections have been obtained from 88 lots of rice, representing 25 varieties (65 lots of milled and 23 lots of brown; each of the 23 is a different variety), after cooking and embedding in Carbowax. The sections have been mounted on more than 2500 slides. About 170 slides (two slides from each of most of the lots) have been stained with acid fuchsin and iodine for demonstrating the distribution of protein and starch, and an examination of these slides is in progress. Those slides not yet stained will provide material for a study of the distribution of fat, pectin, cellulose, and if time permits for a study of other components. A manuscript entitled "Serial sections of cooked rice embedded in Carbowax" was written and submitted to a journal for publication. Another manuscript, "Permanent staining with iodine vapor" is to appear in the September issue of Stain Technology, Vol. 31, 1956.

Analyses of the 74 lots will be completed and the work discontinued.

Publications:

Cooking Rice for School Lunches, Olive M. Batcher, Katharine F. Helmintoller, and Elsie H. Dawson. Journal of Home Economics, Vol. 48, No. 1, 36-37, 1956.

Cooking Rice in Quantity, Food and Home Notes, USDA 3203-55, December 14, 1955.

Cooking White Rice, Processed Publication, ARS 61-2, Revised, September 1956.

Permanent Staining with Iodine Vapor, Ruby R. Little. Stain Technology, Vol. 31, 1956, September.

Development and Application of Methods for Evaluating Cooking and Eating Quality of Rice. Olive M. Batcher, Katharine F. Helmintoller, and Elsie H. Dawson. Rice Journal. In press.

Serial Sections of Cooked Rice Embedded in Carbowax. Ruby Rice Little. Stain Technology. In press.

2. Food Consumption and Dietary Levels of Rural Families — HHE-ARS

Food consumption and dietary levels of rural families in the North Central region has been investigated as a basis for educational programs of teachers, nutritionists and extension workers and for policy and program decisions of USDA administrators and others interested in levels of living of rural families. The data were collected from a sample of 1,152 families in 1952. A report prepared for publication during the year summarizes the information on quantities and expenditures for food used during a week, the amounts that were purchased or home-produced, the nutritive content of the week's food and the variations in these respects among different groups of families. Some of the findings are summarized below.

Of every dollar spent for purchased food by the farm family, 22 cents went for meat, poultry, and fish, 20 cents for fruits and vegetables (including potatoes), 10 cents each for milk, baked goods, and beverages, 8 cents for fats and oils, and the remainder for sugar, flour, cereals, eggs and other foods.

On the average, the food used at home by rural families in the North Central region provided diets exceeding the National Research Council's recommended allowances for calories and 8 nutrients studied, with the farm diets having larger amounts in relation to estimated need than the nonfarm. However, a number of families had diets low in one or more nutrients. One-fourth of both the farm and rural nonfarm diets fell below the NRC allowance for ascorbic acid; one-fifth of the farm and one-third of the nonfarm diets failed to meet the allowance for calcium. One-fourth of the nonfarm families were below the recommended level for thiamine and a fifth for vitamin A, riboflavin, or niacin.

The two bulletins on this survey (the first was reported last year) complete the presentation of the basic data. Attention will be directed next toward estimating and interpreting trends in farm family food consumption.

3. Basic Data for Food and Nutrition Programs — HHE-ARS

Research findings for several projects have been used in the development of a publication, "Essentials of an Adequate Diet," released in June, 1956. The most recent research on human nutritional needs (expressed in terms of recommended dietary allowances), nutritive value of foods, and food consumption habits provides the basis of the recommendations contained in the bulletin. Special emphasis has been given to the nutrients most likely to be short in American diets, and to foods that are good sources of these nutrients. Because different kinds of foods can provide the essential nutrients and because food supplies in this country are ample to provide considerable freedom of choice, the bulletin presents a point system to show how common foods rate as sources of key nutrients. Using this system, foods within the basic

plan can be interchanged to allow for differences in availability and cost of foods, food preferences, and other factors.

This publication was designed as a source book for home economists and nutritionists, in extension and other fields, who are teaching the principles of good food selection. It is the first of a series, Facts for Nutrition Programs, designed to meet the continuing demand for authentic information on food values, diets, and other subjects related to nutrition.

This series will be expanded to cover additional topics and cooperation with information and education specialists in the preparation of popular materials and teaching aids to present the information contained in "Essentials of an Adequate Diet."

4. Facts for Consumer Education HHE-ARS

Another series of publications, Facts for Consumer Education, presents basic research material, by commodity, on consumer buying, nutritive values and use of foods, for use in consumer information and marketing programs. This series has not covered the following foods: Beef, pork, tomatoes, peaches, milk and milk products, and bread.

A publication on potatoes has been submitted for review. At present, no additions to the series are planned.

5. Composition and Nutritive Value of Foods HHE-ARS

Continuing work is required to prepare and keep up-to-date suitable tables of the composition and nutritive value of foods. One of the segments completed during the year was a Handbook on physical yields and losses or changes that occur in food preparation. Information has been brought together from many laboratories on how much meat, fruits, vegetables and other foods purchased on the market can be expected to yield as food ready to eat. The publication "Food yields-summarized by different stages of preparation" gives dietitians and food managers an up-to-date guide for planning food purchases for school lunch rooms, hotels, restaurants, the armed forces, hospitals, and other institutions. The data take account of present-day practices in processing and marketing food and new developments in breeding plants and livestock that affect yields not reflected in earlier less comprehensive summaries of yield data.

Preliminary tables of amino acid content of food were issued in small edition for study and review, including values for 12 amino acids for over 300 food items. This is the first comprehensive table of average values available for calculating the amino acid content of diets or food supplies. In preparation for publication, data for 6 more amino acids and several additional food items are included.

Progress is being made in establishing channels for securing unpublished analytical data to use in a contemplated revision of Handbook 8, "Composition of Foods, Raw, Processed, Prepared."

Publications:

Food Expenditures of Households in the United States. Preliminary Report, Household Food Consumption, 1955, August 1956.

Food Consumption and Dietary Levels, Rural Families in the North Central Region, 1952, by M. Orshansky, C. LeBovit, E. C. Blake, and M. A. Moss, AIB, 1956.

Effect of Food Losses on Nutritive Content of Diets in Four Institutions, Constance L. Brine and Edith B. Tate, Jour. Amer. Dietet. Assoc. 32, January 1956.

Food Expenditures in Four Institutions, Faith Clark and Edith B. Tate, Jour. Amer. Dietet. Assoc., September 1956.

Nutritive Values of Per Capita Food Supply, table and Nutritional Review in National Food Situation, October 1955.

Nutrients Contributed by Major Food Groups--A Reflection of Changing Food Habits, Eloise Cofer, National Food Situation, October 1955.

Essentials of an Adequate Diet--Facts for Nutrition Programs, by L. Page and E. F. Phipard, ARS 62-4, June 1956.

Diet and Serum Cholesterol in Men: Lack of effect of dietary cholesterol, A. Keys, J. T. Anderson, O. Mickelsen, S. F. Adelson, and F. Fidanza. Jour. Nutr. 59(1) 39-56, May 1956.

Bread, Facts for Consumer Education, by I. H. Wolgamot and L. J. Fincher, AIB 142, November 1955.

Food Yields, Summarized by Different Stages of Preparation, by R. Pecot and B. K. Watt, AH 102, July 1956.

B. Composition and Quality Preservation

Studies of rice composition are important requisites to the solution of problems in rice technology such as discoloration from heat damage, bran adhesion, behavior of rice in processing, and stability of various rice products. The Committee has given this type of research a very high rating, and the Western Branch has devoted as much attention to this effort as resources have permitted.

1. Acidic Constituents of Western Rice WU-ARS

Acidic constituents of rice, although small in quantity, are important in "browning", souring, and rancidity development. An improved method for assaying simultaneously the individual amino acids of rice samples has been developed.

A comparison was made between the amino acids in fresh and stored parboiled rice. Storage apparently reduces the total amount of these compounds, with the greatest reduction occurring in asparagine, methionine, and cystine.

Procedures have been improved for analysis of minute quantities of individual non-amino organic acids of rice. The method affords individual determination of such non-amino organic acids as succinic, formic, acetic, o-coumaric, lactic, pyrrolidonecarboxylic, oxalic, malic, citric, and phytic acids already identified in rice and rice by-products.

The relation of amounts of the non-amino acids to other changes occurring in rice and its by-products will be examined.

Determination of Amino Acids by Ninhydrin Oxidation and Gas Chromatography. I. R. Hunter, K. P. Dimick, and J. Corse, Chemistry and Industry 16, 294, April 28, 1956.

Proportional Divider for Rapid Determination of Chromatographic R_f Values. D. F. Houston. J. Chemical Education 32, 411 (1955).

Chromatographic Chamber for Simultaneous Preparation of Many Paper Chromatograms. I. R. Hunter, D. F. Houston, and H. S. Owens. Anal. Chem. 28, 283 (1956).

2. Quality Preservation of Rough Rice WU-ARS

Current urgent needs for prolonging the stability of rough rice have led to continued studies of changes in quality characteristics of rice held under different conditions. Investigations involved open-air bin scale tests as well as laboratory tests under closely controlled environments. Financial support was again granted by the Western rice industry in these efforts. Bin experiments were conducted cooperatively with the University of California College of Agriculture, and were made at the Biggs Rice Experiment Station operated by the California Cooperative Rice Research Foundation. U. S. grade determinations were made by the Grain Branch of AMS. Details of bin construction and operating details were described in the report for 1953-54.

The practical utility of the findings of the three years rice storage is already becoming evident. When the Commodity Stabilization Service assumed ownership of about three million sacks of Western rice on May 31, it requested all available information obtained at the Western Utilization Research Branch on the storage requirements of rough rice to use in specifying conditions under which this rice will be maintained until it is processed or released into commercial channels.

(a) Rice Held in Bins. The prupose of the third year of tests was to learn what changes occur in rough rice under the conditions imposed, when it is held for periods of as long as two years. Heretofore, rice was maintained experimentally in bins for not longer than 9 months, and in no case was deterioration to below U. S. Grade No. 2 observed. To obtain more conclusive data on rate of quality loss (and accompanying changes in composition and properties) than has been possible in previous years, rice will not be unloaded from the bins until it shows quality deterioration to U. S. No. 4 unless the tests are concluded before this point is reached.

Rice of the 1955 crop was the subject material for the new series of tests starting in November. As in the previous years, it was held under three general conditions:(1) flat-stored, (2) turned, and (3) aerated. Moisture contents of the artificially dried rice in each group of bins were about 12, 14, and 16.5 percent.

Up to August 15, 1956, most of the bins were still U.S. No. 1 grade. The high moisture flat-stored bin, however, had deteriorated to sample grade (below grade 6) from U. S. No. 1 in July. Quality loss was accompanied by pronounced heating to about 119° F., development of high fat acidity, relatively high mold count, and almost complete loss of viability. The high moisture turned bin had begun to discolor in this period. In this bin, original dockage augmented by hulls produced by the pneumatic loader tender to accumulate in columns, and to cause heating above the general level of the other bins.

Studies on the bin storage of rough rice will be continued until the current two-year experiment is completed.

Publication:

Storage Behavior of Rice in Experimental Bins, 1954-55. E. B. Kester, D. F. Houston, R. E. Ferrel, I. R. Hunter, and D. C. Finfrock, Rice Jour. 59, (9) 24-27 (1956)

(b) Rice Held Under Laboratory Conditions. The study of separate and simultaneous effects of controlled temperatures and moisture contents on changes in the composition and quality of stored rough rice, on which progress was reported last year, was continued. Storage of rice of the 1954 crop at 70 and 90° F. at four moisture levels was concluded after 14 months. All samples were examined monthly to ascertain changes in viability, fat acidity, sugars, and mold and yeast populations. The following changes from initial values occurred; complete loss of viability

in all samples; increases in acidity from 49 to 1350 percent; increases in reducing sugars from 0 to about 80 percent; losses of non-reducing sugars to about 92 percent; large increases in molds in all but the lowest moisture 70° F. sample which remained substantially zero; and almost complete disappearance of yeasts. The highest moisture 90° F. sample which was aerated was so badly decomposed it had to be discarded after 6 months storage. Reducing sugars of this sample showed first an increase, then a decline in the final month of storage to below their starting value. Extent of changes increased as moisture or temperature increased.

A similar study was started on 1955-crop rice in November 1955 to observe rice of another crop year and to extend the data by increasing the range and number of storage temperatures. Four sets of rice samples of four moisture levels were stored in loosely covered cans at 60, 77, 90 and 100° F. respectively. In addition to the tests performed the previous year, periodic tests were also made of protein solubility. Viability losses in 6 months ranged from zero to 100 percent, the samples in the 90° and 100° F. series being most affected. Where fat acidity developed, the highest rise occurred in the highest moisture, highest temperature sample which showed an increase of almost 15-fold. The two lowest moisture 60° F. samples showed little if any increase in fat acidity. In this period marked increases in reducing sugars and losses of non-reducing sugars were observed, principally in samples which showed total loss of viability. An exception was a sample of 9 percent moisture rice held at 100° F. which showed little or no change in either reducing or non-reducing sugars from initial values. Non-reducing sugars almost disappeared in the highest moisture 100° F. sample. Mold counts were noticeably elevated only in the highest moisture samples of the 77, 90, and 100° F. series and all yeast populations were reduced from initial values. Results in general confirm those of the two previous years' studies.

Laboratory studies now in progress on the storage of rough rice will be continued with the object of completing them during the coming year.

(c) Laboratory Studies of Rice Held at Low Temperatures. The low-temperature storage was continued to develop information useful in preservation of genetic stocks or research reference material. Rice samples of 4 moisture contents (12.1, 13.2, 15.0 and 16.2 percent) stored 20 months at -20, 20. and 34° F. showed little evidence of change in measured properties. Yeast populations which had shown increases at 12 months declined in most instances in the succeeding 8 months to less than the original values. Viability remained at or slightly above initial levels.

It is contemplated that these low temperature storage studies will be completed during the coming year.

Publications:

Rice Investigations at Western Utilization Research Branch. E. B. Kester. Rice Journal (Annual Issue) 1956.

3. Drying of Rough Rice WU-ARS

Drying of combine-harvested rice has received major attention as a research topic because of its economic importance. Earlier studies of the drying procedure were continued and expanded to show what improvements could be made that would reduce costs, increase capacity, or afford a higher quality product, and to apply the experimental procedures to rice crops of more than one year. Pilot-plant drying studies conducted on California rough rice harvested in the 1953 and 1954 seasons have been discussed in previous reports. The studies included the effects of air flow rate, air temperature and humidity, and number of drying stages on head yield and drying time. The results were summarized in the form of diagrams suitable for guiding rice drier operators in selecting optimum drying conditions according to their need for additional drying capacity or higher product quality.

Equipment and procedure for running milling tests on dried samples of rice have been modified in accordance with the current method recently adopted by the Agricultural Marketing Service Grain Division in San Francisco and by the California State Grain Inspection Laboratory for Western-grown rices. The new method, however, while in general use in California has not yet been adopted officially by the AMS as an amendment to the Rice Inspection Manual. It differs from the old procedure in that the rice is milled to a fixed reduction in volume rather than for a fixed time. All milling tests in present work are run by both old and new methods to provide a correlation for comparison of past, present, and future studies on rice drying.

During the 1955 season, the information developed in the pilot-plant scale drying studies was applied on a plant scale, under an informal memorandum of understanding with a rice growers cooperative in California. The purpose was to demonstrate the applicability of our work to commercial conditions and scale of operation. The demonstration was successful in that plant capacity was increased 60 percent over normal operation without loss in rice quality, by increasing the number of drying stages and the drying air temperature. Further improvement in plant operation could not be shown because of limitations of the drying system. This is strong but not conclusive evidence of the validity of the information developed by the Western Branch. Conclusive evidence will require similar work in other types of driers and in other growing seasons.

The need for additional drying capacity in commercial plants was also shown during the work at the cooperative drying plant. Analysis of plant records showed that rice received at the plant during 1955 deteriorated appreciably during field drying. For each loss of 1 percent moisture by field drying after the rice reached maturity, 1.5 percent loss occurred in head yield. Since a 1 percent change in head yield means about $500,000 to $750,000 annually to the California rice industry, the importance of harvesting at the proper time is obvious. Harvesting at the proper time is possible, however, only if adequate drying capacity is available in the drying plants.

Further pilot-plant scale studies on rice drying were also conducted during the year. Emphasis was on the minimum time that rice must be held between drying stages ("tempered") to allow redistribution of moisture within the individual grains. Tests reported last year indicated that rice is adequately tempered in 10 to 12 hours at a temperature in the range of 80° to 90° F. More extensive work during this year shows that rice is adequately tempered in 4 hours at 105° F. and in 8 hours at 75° F. Since commercial practice involves tempering for periods of 24 to 48 hours and even longer, shorter tempering periods will (1) allow more flexibility in drying plant operations, (2) reduce opportunity for spoilage of rice before drying is completed, and (3) increase plant capacity in many custom drying plants where capacity is presently limited by available storage or tempering capacity rather than by drying capacity. Tempering at 105° F. also reduced total drying time substantially by eliminating the portions of the drying cycle ordinarily devoted to heating the rice to its drying temperature. Head yield, seed viability, and time required to complete drying are the criteria used to date to show that short-time tempering is equal to or better than long-time tempering.

Storage tests are in progress as an additional comparison between the two types of tempering. Similar tests will be made on rice from different growing seasons to determine whether the present findings are broadly applicable.

Publications:

Drying Characteristics of Western Rice - Colusa 1600 Variety. J. H. Thompson, A. H. Brown, W. D. Ramage, R. L. Roberts, and E. B. Kester. Rice Jour. 58 (11): 14, 16, 18, 19, 52(1955).

Drying Characteristics of Western Rice - Caloro Variety. I. Equal Moisture Removal and Constant Air Temperatures in All Passes. T. Wasserman, A. H. Brown, D. F. Houston, and R. E. Ferrel. Rice Journal 59 (3), 12-16 (1956).

Drying Characteristics of Western Rice - Caloro Variety. II. Varying Drying Air Temperature and Amount of Moisture Removed in Each Pass. T. Wasserman, A. H. Brown, D. F. Houston, and R. E. Ferrel. Rice Journal 59 (4): 41-45 (1956).

4. Chemical and Physical Properties as Related to Processing Qualities — SU-ARS

Continuation and expansion of domestic markets for milled rice depend upon the ability to produce rice of uniform and good cooking quality. One of the varieties that is popular with farmers, Century Patna, has been a source of difficulty in processing because its cooking quality was inferior, based upon American standards, to other long-grained rices and, moreover, was not uniform. Consequently a great deal of interest has been aroused in trying to eliminate this difficulty both by breeding new varieties that will not possess this processing

difficulty and yet will retain the cultural advantages of the present Century Patna and also by trying to understand better the reasons for differences in cooking quality. As part of this program, work was undertaken on a determination of moisture relationships in rices of different varieties and different processing quality, and of the chemical changes that take place during cooking or exposure to water at different temperatures. It was found that under conditions akin to cooking from 11 to 16 percent of the total starch is lost to the cooking water. The Rexora, a good-processing rice, lost more starch to the cooking water than did Century Patna, a poor C-1 processing rice. Moreover it seems that Century Patna requires longer time of heating to acquire the same consistency, softness and water uptake. Investigation of the cooking quality of many popular varieties of rice of different grain types and processing history indicates differences among samples within a given grain type as well as among the different grain types. Processed rices (pre-cooked) show unusually high water uptake characteristics.

From this work and from cooperative work in other institutions there is developing the realization that there are differences in the chemical properties of rices of different varieties which are reflected in the processing behavior. This information should enable identification of good and poor processing rices to aid in the selection of those that should be grown in larger amounts. More important than this, however, this type of information lays the basis for further research on development of new products from rice such as quick cooking, frozen and other products designed to appeal to the convenience of the housewife and which may have the affect of increasing the consumption of rice in domestic markets and foreign markets.

Publications:

Rice Milling. Effects of Milling Conditions on Breakage of Rice Grains, by H. S. Autrey, W. W. Grigorieff, A. M. Altschul, and J. T. Hogan. Jour. Agric. & Food Chem. 3(7): 593-599. 1955. Reprinted in World Rice 2(11): 4-5. ;0, 1955.

Hygroscopic Equilibria of Rough Rice at Elevated Temperatures, by J. T. Hogan, and M. L. Karon. Jour. Agric. & Food Chem. 3(10): 855-860. 1955.

Ethanolamines and Other Amino- and Hydroxyl-Containing Compounds in the Refining of Rice Oil, by E. R. Cousins, R. Prachankadee and S. Bhodhiprasart. Jour. Amer. Oil Chem. Soc. 32(11): 561-564. 1955.

Effects of Heat Treatment on the Viability of Rice - A report of Research and a Literature Survey, by V. H. McFarlane, J. T. Hogan, and T. A. McLemore. USDA Tech. Bulletin No. 1129, 1955.

C. Development of New and Improved Products and Processes

1. Instant-Cooking Rice Breakfast Cereals WU-ARS

Production of "instant" rice breakfast cereals (hot type) offers a potentially large-scale consumption of rice in a food field where it now attracts only a meager share of the market. Research in the development of such cereals has been concerned with the problems of obtaining uniformity of product, maximum expansion of grains in puffing, and most desirable flavor characteristics. The earlier used method of preparation has been simplified by precooking the rice with steam at atmospheric pressure.

Hydration rate of the instant rice cereal is dependent on porosity of the granules, which in turn is dependent on the degree of expansion of the precooked rice. Considerable effort has therefore been directed to adjust processing conditions so that maximum expansion of grains is attained in the expansion step. In its present stage of development instant rice cereal is prepared by first soaking whole rice, then carefully cooking and drying it. The dried, cooked rice is expanded in hot air, after which flavoring materials are added, the rice is toasted and the kernels ground to appropriate sizes. Length of soaking and cooking, rate of drying, and percent moisture in the rice prior to expansion, are all factors that bear on the expansibility of rice. Drying must be fairly slow -- otherwise transverse cracks develop in the grains. During puffing, the steam pressure within the individual grains is reduced at or near the checks and lowers expansion volume. By controlling drying conditions, a three-fold volume increase has been attained, but from previous work on parboiled rice it is considered possible that four to five volumes may be possible.

A sample of instant rice cereal made from brown rice, flavored with malt syrup and toasted, has been prepared and submitted to the Army Quartermaster Food and Container Institute for preliminary appraisal of acceptability. As this product has a fat content of 2 percent or more, it will be necessary to conduct stabilization studies using presently available antioxidants that are permissible for use in foods. These studies are being planned.

Additional studies on development of new rice products, such as anhydrous products having minimum packaging requirements, will be undertaken as soon as practical.

3. Food Products Containing Waxy Rice Flour WU-ARS

Previous studies showed the superiority of waxy rice flour for maintaining the smooth consistency of foods such as sauces, gravies, and puddings at 0° F., whereas at 10° F. liquid separation and curdling were prevented for periods of only a few weeks. Since precooked frozen foods are commonly exposed to temperatures above 0° F. during commercial distribution and storage, experiments were undertaken to devise means of making these foods more stable to such adverse temperature conditions. Various substances such as gelatin, pectin,

gums, and Irish-moss extractives, that are known to have stabilizing properties under some conditions, were tested at 10° F. in white sauce and a pudding thickened with waxy rice flour. At concentrations of 0.4 to 0.5 percent the various additives had little or no effect in increasing storage stability, but citrus pectin, gelatin, and gum tragacanth at 1 percent were effective, in that liquid separation was prevented for 3 to 5 months and a smooth non-curdled appearance was maintained for 2 to 5 months. In the somewhat limited tests conducted, low-methoxyl citrus pectin was the most effective additive. Thus the use of waxy rice flour and a suitable additive is a promising method of preventing texture changes in thickened frozen foods at temperatures encountered in commercial distribution.

Work will be continued on utilizing the unique characteristics of waxy rice in the development of new and improved food products.

Publications:

Texture stability in frozen sauces, gravies, and other foods. H. L. Hanson. Precooked Frozen Foods, A symposium, M. Bolluman and M. S. Peterson, Editors, Advisory Board on Quartermaster Research and Development, Committee on Foods, National Academy of Sciences - National Research Council Washington, December 1955.

Texture stability of thickened precooked frozen foods as influenced by composition and storage condition. H. L. Hanson, L. R. Fletcher, and A. A. Campbell, Abstract, Food Tech. 10(5) (1956)

Frozen cooked rice. E. B. Kester and M. M. Boggs. Precooked Frozen Foods. A symposium, M. Bolluman and M. S. Peterson, Editors, Advisory Board on Quartermaster Research and Development, Committee on Foods, National Academy of Sciences - National Research Council, Washington, December, 1955.

4. Canned White Rice WU-ARS

Plans have been formulated in cooperation with the Market Development Branch of AMS and the California rice industry for a market test of a canned California rice product manufactured by a process developed at the Western Utilization Research Branch. This process was described in previous reports. The product has good texture, flavor, and keeping qualities. Its excellent characteristics, plus the fact that it is a convenience item (it may be prepared for serving in two or three minutes) should increase the popularity of rice among domestic consumers. At a meeting on July 10 attended by rice millers, representatives of the canning industry, and AMS and Laboratory personnel, details of the proposed market test were outlined. Subsequently the California rice industry agreed to support this project with funds to purchase and can the rice, and to promote its sale in the city selected for the test. Arrangements to activate this survey are now in progress.

D. Utilization of Byproducts and Disposal of Wastes

1. Rice Oil SU-ARS

No further work was done this year on refining of rice oil or on isolation of emulsifying material in rice oil. The method developed (and reported last year) for reducing refining loss by adding certain cheap materials such as molasses provides an economic basis for processing of rice oil.

Publications:

Rice Quality and Rice Oil. Research at the Southern Regional Research Laboratory, by R. W. Planck. Rice Jour. 58(7):40, 41, 98. 1955.

III. MARKETING RESEARCH

A. Marketing Costs, Margins and Efficiency

1. Rice Marketing Efficiency — OC-AMS

Exploratory work was started in the fall of 1956 to determine the effect upon the utilization of rice resources of variations in volumes, seasonal patterns and market outlets which have been associated with the operation of Federal programs. Information has been assembled from published sources to show the structure and characteristics of the industry and some information has been obtained to provide a basis for estimating the capacity of existing facilities. Information also has been collected on legislative measures which govern the operation of Federal programs which affect rice. Data for the period since 1940 have been obtained on prices, supplies, location of stocks, millings, and dispositions. Work also has been started to establish trends and seasonal indices for the period during which Federal programs exerted little or no influence on rice markets as a basis for evaluating the effect of these programs. Collection of information by personal interview of rice firms is expected to get under way during the late winter and spring of 1957.

2. Effect of Marketing Practices for Rice on Returns to Producers and on Grade of Product — OC-AMS & AES Texas

Information on costs and effect on market grade of the operation of 43 rice farm drying and storing installations in the Gulf Coast area of Texas has been obtained for a second crop year in cooperation with the Texas Agricultural Experiment Station. Data are being summarized and a report covering the findings of the 1954-55 and 1955-56 marketing years will be prepared for release early in 1957. Indications are that the results outlined in last year's report to this committee are fairly well substantiated by the observations obtained this year. The project will be terminated with the publication of the report.

B. Improvement and Evaluation of Product Quality

1. Storage Requirements BS-AMS

A preliminary survey was made of rice storage methods and problems in Louisiana and Texas. Arrangements are being made to initiate research in this area to study the various factors in storage that cause deterioration and to develop methods to prevent losses and maintain quality.

In packaging tests made in cooperation with Louisiana Rice Experiment Station, Michigan State University, and American Viscose Corporation, Duplex 300 MS-3 cellophane or equivalent gave the best results for 1 and 2-pound moisture-proof bags. Duplex 300 P-1 or equivalent gave excellent durability but permitted greater weight fluctuations or loss and gain of moisture in the rice. The research was completed and a report was issued.

2. Insects in Stored Rice BS-AMS

Work on this subject has been carried on at Houston, Texas since 1952. Close cooperation is maintained with USDA engineers stationed at College Station in conducting studies where aeration systems in bulk storages are used to distribute fumigants.

Much of the year has been devoted to studies related to the fumigation of rice with HCN in place of methyl bromide. When the tolerance of inorganic bromide residues in rice resulting from fumigation with methyl bromide was announced early in 1956, it became necessary to abruptly stop the use of methyl bromide for the monthly treatment of CCC-owned rice in storage. Analysis of residues revealed that they increased with each fumigation, and soon exceeded the established tolerance. HCN was the most plausible replacement, and dosage schedules and procedures were established on the basis of known information. Research was immediately begun so that the procedures could be modified at any time they showed evidence of not protecting the rice.

In evaluation studies of routine fumigations of rough rice warehouses with methyl bromide, prior to the conversion to HCN, it was demonstrated in one set of tests that releasing the fumigant in the headspace of a tightly built warehouse, good distribution was obtained merely by gravity settling, without the use of fans. The warehouse was well filled with milled rice stocked 36 pockets high in some parts. In a second set of tests it was demonstrated that a warehouse with walls made of corrugated metal sheets, could be sealed tight enough to permit successful fumigation. In this instance a crew of men worked a month sealing the wall laps, windows, doors, and ventilators, and the job was tight enough to permit fumigation on a windy day.

It is planned to further expand this work. During the year a professional member was added to the staff in preparation of this expansion, and the laboratory was moved to better quarters in the same building

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where the Houston Rice Grading Office is located. Because of the large holdings of surplus rice by CCC, it is anticipated that their storage problems, and the impact of the surplus on trade handling practices, will create an urgent need for a broader research program. (See proposal for committee consideration.)

3. Attraction of Stored-Products Insects with Electromagnetic Radiation — BS-AMS

Work has continued on measurement of the response of insects to monochromatic light in cooperation with AERB-ARS and the Texas Agricultural Experiment Station. Instrumentation and techniques of testing have been developed for determining the response of insects to light. Considerable difficulty has been encountered in developing the necessary instrumentation and in devising operating procedures to properly test the response of different insects. However, these problems have been overcome and work in proceeding on the response tests. The response of the Almond Moth (Ephestia Coutella) has been determined for wavelengths from 340 to 500 millimicrons. The response curve peaks near 400 millimicrons with a rapid fall off at the shorter wavelengths and a much more gradual fall off at the longer wavelengths. Therefore, a light source rich in violet light should be the most attractive to the Almond Moth. Tests are now being made on other stored-products insects and will be continued for all the flying insects of economic importance.

4. Simple Fat Acidity Test — BS-AMS

Fat acidity has been shown to be a useful index of soundness of grain but available methods for determining fat acidity are not practical for routine use. The simplified and rapid fat acidity test using a grinder-extractor and graduated dropper continues to appear satisfactory. With the rapid method, six to eight determinations can be made in an hour depending upon the operator. The method was tested in the field for inspecting bins of corn in storage. No difficulties were encountered in the use of the method.

Data has been collected in the study of the moisture content at the time of extraction in relation to fat acidity values. This study has shown that the most consistent fat acidity values are obtained when the moisture content of the grain is 10 percent or less. Correction factors have been determined for wheat and barley which can be applied at moisture levels above 10 percent. An analysis of the data from the survey of grain of varying degrees and types of damage shows a good correlation between fat acidity values and some types of damage. A paper on this work as well as other phases of the work completed on this project was presented at the annual meeting of the American Association of Cereal Chemists.

Future research will cover a study of the relationships between moisture and extractible fat acidity for other grains. It is also planned to continue the study of fat acidity values of grain of different types and degrees of damage.

Publications:

An Improved Rapid Method for Determining Fat Acidity in Grain, 2 pp. mimeographed publication. October 1955.

The Application of the Fat Acidity Test as an Index of Grain Deterioration. Doris Baker, M. H. Neustadt and Lawrence Zeleny, In Press.

5. Methods for Determining Moisture Content in Grains, Seeds and Other Farm Crops — BS-AMS

The Karl Fischer method which has been developed was applied to the different grains. This phase of the work has been completed and a procedure has been developed and tested. A paper describing the work was presented at the annual meeting of the American Association of Cereal Chemists. Moisture determinations were made on hundreds of samples of the various grains to ascertain the optimum conditions of temperature and time in an oven which will yield the same results as those obtained with the Karl Fischer method. Work has continued on the measurement of weight changes in grain when samples are equilibrated at various humidity conditions.

Work has also continued on the dielectric measurement of moisture content of grain. The instrumentation for measuring the dielectric properties of grain has been revised to increase greatly the sensitivity. Studies with the revised instrumentation indicate that more precise measurements are possible if the effects of the orientation of the grain in the test cell can be reduced. As a result the test cell has been modified and methods of handling the grain have been developed. These new techniques are now being tested.

A brief exploratory study has been made of the possibility of using infra-red absorption measurements to indicate moisture content. With the use of new instrumentation developed under another project it appears possible to measure moisture content in grain by such an absorption measurement.

Work will continue on the development of practical oven methods which will uniformly give the same results as the basic Karl Fischer method. Relative humidity equilibrium studies will be continued. It is planned to continue research also on the dielectric and the infrared absorption measurements of the moisture content of grain, seed and other farm crops.

Publications:

Grain Moisture Determination, Karl Fischer Method. 5 pp. Mimeographed publications. July 1956.

Application of the Karl Fischer Method to Grain Moisture Determination. Joe R. Hart and M. H. Neustadt. In Press.

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C. Improvements in Market Organization and Facilities

1. Improved Methods, Equipment and Facilities for the Off-Farm Conditioning, Handling and Storage of Rice — TF-AMS

Studies were continued during the past year, in cooperation with the Texas Agricultural Experiment Station, in developing more effective methods and equipment for aerating undried, partially dried, and dried rice. Work also was initiated to develop improved off-farm drying techniques and more efficient handling methods and equipment.

Studies of existing aeration systems were made to determine the amounts of air supplied, power requirements, cooling rates, quality of rice, and methods of operation. Some important weak points noted were improperly designed systems, wrong types of fans, and motors that were much too large.

In one existing system studied, a 15-horsepower fan unit rated to deliver 16,000 cubic feet of air per minute was used. This fan was found to deliver only 120 cfm when only used on one bin, and it only delivered about 1600 cfm (or roughly 1/10 of what it was designed to deliver) when used simultaneously on 14 bins. It was calculated that a 5-horsepower motor would be adequate if the system was properly designed.

At another storage rice was turned back through the drier with the heat off to cool it. Studies showed that the aeration system would do as good a job of cooling, and at much less expense, although a 30-horsepower motor was used to pull the fan when only 20-horsepower was needed.

Studies in a flat storage again showed the existing aeration systems to be improperly designed and equipped with motors which were too large. A new system was designed that supplied more air with a 1/2-horsepower fan unit than did one of the existing systems equipped with a 10-horsepower fan unit. As a result of these studies this firm saved 50 percent on the cost of installing aeration in 26 new bins. Also, rice stored in bulk in this flat storage, and aerated, graded consistently higher than rice stored in bags.

Moisture samples taken at all storages under study showed no consistent trend toward gaining or losing moisture as a result of aeration. Rice which was cooled to about 50° ramained below 70° F. for more than six months. Six to 7 months is about the normal storage period at country elevators. Holding rice below 70° F. is advantageous from the standpoint of maintaining market quality and preventing damage due to insects.

Work was started toward developing improved techniques for drying rice at commercial firms. A survey of existing methods and equipment is being made, in cooperation with the Agricultural Economics Department, Texas Agricultural Experiment Station. The results of the survey to date indicate considerable variation in the operating procedures of driers

surveyed. Drying air temperatures, temperatures of dried grain coming from the drier and the number of passes through the drier vary considerably between driers. Results of the survey will be used as guides and bases for setting up detailed and comprehensive drying studies. The studies will be conducted in commercial storages and in the laboratory.

Handling studies also are started in several storages. Existing methods and equipment for receiving, turning and shipping rice will be studied first. Information from these studies will provide a basis for determining how improvements can be made in existing handling methods and equipment and for developing improved methods and equipment.

It is estimated that between 25 and 50 percent of the cost of drying and storing rice could be saved with improved drying, handling and storing practices. The estimated production of rice in Texas in 1956 is nearly 28 million barrels. It is estimated that it will cost about 29 1/3 million dollars to dry and store the crop. If this cost could be reduced 25 percent approximately 7 1/3 million dollars could be saved.

Studies underway will be continued and expanded as time and personnel permit. It is planned that this work will be extended to Arkansas and Louisiana during the next year. Studies also are planned to compare costs of storing in flat and upright storages. These studies are needed because upright storages built in 1955 cost as high as $5 per barrel capacity, including handling equipment. Flat storage, including handling equipment, built in 1956 cost as little as $2 per barrel capacity. However, handling costs for flat storage appear to be higher than those for upright storage. (See proposals for committee consideration.)

2. Transportation of Rough Rice in Louisiana and Texas TF-AMS

A report was published on this study. It compared sacked and bulk rough rice loading and unloading methods, and the effect of sacked and bulk handling on railroad car detention and milling schedules. The report also analyzed the turnaround time of covered hopper cars for rough rice traffic in Arkansas.

Time studies showed that an average of 24 man-hours are required to load and unload a boxcar of 420 sacks of rough rice. For the same quantity of bulk rice in boxcars, 6 man-hours are required; in covered hoppers, 4 man-hours. At $1.25 per man-hour, the labor costs to load and unload 420 sacks and the equivalent in bulk are as follows: $30 for sacked, $7.62 for bulk in boxcars, and $5.20 for bulk in covered hopper cars.

A car detention study of 2,886 boxcar loads of rough rice received by mills in Houston, Texas, approximately half in sacks, during the 1954 harvest showed an average of 4.5 days of constructive and actual placement for unloading. This is 3 times longer than boxcars of bulk rice are held for unloading in Arkansas, according to a survey made by the Association of American Railroads cooperating in the study.

A comparison was made of the effect on milling operations of sacked and bulk rough rice receipts. The milling schedules and outbound shipments of milled rice in Arkansas, with 100 percent bulk receipts, were scarcely affected by extra large rough rice receipts during the short harvest period. In Texas and Louisiana, with approximately half-sacked and half-bulk receipts, the rice mills felt the impact of the harvesting period.

The improvised use of covered hopper cars in Arkansas was analyzed. It indicated the possibility of developing with more experience better loading and unloading methods, further to reduce these costs. A survey of car utilization jointly made with the AAR showed that the covered hopper car obtains an earlier release and shorter turnaround time than the boxcar.

No further work planned.

Publication:

Railroad Transportation of Rough Rice in Louisiana and Texas, J. Edward Jay and Mark R. Enger, Marketing Research Report No. 136, September 1956.

3. Economic Survey of Rice Transportation in the South — TF-AMS & FCS

An economic survey of the transportation of rice in the South, conducted jointly with the Farmer Cooperative Service, has been published. It shows that most of both the dried rough and the milled rice shipped within and from the Southern States is still transported by railroad. The survey indicates the extent to which this is true for each Southern rice State. More importantly, the reasons for this continued dominance of the rail carriers is also shown. The principal reason is their lower rates in comparison to those charged by trucks. Other reasons include greater efficiency in the employment of loading and unloading crews (especially for large shipments), the fact that available facilities in the rice trade were set up for rail movement, and the fact that railroads generally have had a more dependable supply of equipment. It thus appears that traffic can be held by the railroads through lower rates and superior service except where other forms of transport are at a decided inherent advantage. An instance of the latter situation is that rice shippers or receivers often prefer trucks for small shipments and short hauls. The conclusions of the survey should prove valuable to the several carriers by showing (1) what the trucks would have to do to obtain a larger share of the Southern rice traffic; and (2) what the trucks and the railroads would each have to do in order to improve their competitive position for other traffic. Furthermore, if these findings were put into effect by the carriers in their competition for traffic, the growers, processors, distributors, and consumers would benefit from lower rates and better service.

Even though the railroads generally offer the South's rice shippers lower rates than do the motortrucks, the railroads find this business highly profitable. For hauling rice, the railroads got twice the

amount of their out-of-pocket costs and 30 percent more than their fully distributed costs, including a fair return on their investment.

No further work planned.

Publications:

Transportation of Rice in the South: An Economic Survey, Ezekiel Limmer and Robert J. Byrne, Marketing Research Report, 1956.

D. Market Development and Collection, Analysis and Dissemination of Market Data

1. Market Test and Consumer Acceptance of Canned Precooked Rice — MD-AMS

Work has been initiated in the past year to appraise the market potential for a new rice product (canned precooked rice) in order to evaluate the possibilities for expanding domestic consumption of rice by the introduction of a new rice food product.

Canned precooked rice is a development of the Western Utilization Research Branch of the Agricultural Research Service. This product has several attributes which fit into the trend of convenient food products for the housewife. Canned rice can be prepared for table use in much less time than rice products currently on the market. In addition, the product allows even the inexperienced housewife to turn out a dry, fluffy product deemed so desirable by homemakers. Also, the processing imparts, even to the short-grained California rice, dry, fluffy characteristics which make it more suitable for the domestic market. A market test of the product is needed to determine its acceptance in an actual marketing situation as a prerequisite for commercial production.

The product will be market tested in one or more cities with populations ranging from 50,000 to 150,000. Audited sales of the test product and closely competing products from a sample of retail stores and a consumer survey of a probability sample of households in the test area will determine, among other things: (a) volume of sales of canned precooked rice, (b) amount of sales in relation to competing products, (c) the effect of advertising, (d) the proportion of homemakers buying the product and the rate of repeat purchases, (e) the reaction of consumers to the product, and (f) whether the sales of the new product are a net addition to the consumption of rice or only replacing demand for existing rice products.

Contracts have already been made with the various segments of the rice industry to provide the funds necessary for promotional activities attending the introduction of the product in the test market(s).

The field test of the product is expected to begin in early 1957.

2. Basic Characteristics of the Rice Market — MD-AMS

In order to provide fundamental information to the rice industry to serve as guides for marketing decisions and promotional programs, work has been initiated to establish marketing patterns for rice by the collection and publication of distribution data, by States, of rice for direct food use, from rice millers and repackagers. Data will also be collected on the amount of rice entering into reprocessing uses such as soups and cereals. It is expected that a report on rice marketing patterns for the 1955-56 marketing year will be published in early 1957. Work on this project will be continued and household data obtained from the 1955 national family food consumption survey will be analyzed to determine usage of rice by income levels and other factors associated with rice consumption.

3. Effects of Advertising and Promotional Programs on the Retail Sales of Rice — MD-AMS

The purpose of this research was to measure the effectiveness of merchandising, promotional, and advertising programs on the sale of and consumer demand for rice through retail food stores. Advertising and promotional programs conducted for the Texas Rice Promotion Association are being evaluated by means of retail store studies before promotion, during promotion, and after the promotion period is ended, in Cleveland, Ohio. Each study covers a 2-week period and data are being obtained indicating sales of rice, retail price, display space allocated to rice, and also sales of and display space allocated to a major competing commodity, potatoes. These data will provide an indication of change in the level of rice sales at three different times periods and the effect of advertising and promotion on the movement of the commodity.

It is contemplated that the work on this project will be completed in the fall of 1956 and a report issued early in 1957.

4. 1955 Food Consumption Survey — HHE-ARS
MD & AES-AMS

The data on food consumption obtained from the 6,000 households included in the 1955 survey have been prepared for tabulation, and a preliminary report has been completed. This is the first nationwide study of food consumption since 1942 that covers rural as well as urban households. The survey will provide information on the food consumed during a week, with reporting of the kinds and quantities of food in enough detail to serve the needs of home economists, nutritionists, and those concerned with marketing agricultural products. Consumption of rice will be shown.

The preliminary tables from this survey indicate that food expenditures of housekeeping families in the U. S. averaged $27 a week in the spring of 1955. About $22 of this was for food consumed at home. The remainder, $5, was spent for meals and between-meal food away from home. With average size of the household at 3.43 persons, average expenditure per person amounted to $7.89 a week for all food. Of this, $6.50 was spent for food to be prepared at home, and $1.39 for food consumed away from home. The tables included in this report also made possible comparison of rural and urban, regional, and income groups as to family food expenditures.

The food expenditure increase since the previous nationwide survey in 1942 indicates the effect of both higher food prices and the use of more expensive foods. In 1955, average food expenditure was about three times the average of $10 in 1942. A more precise comparison can be made for urban families of two or more persons. They spent $13 in 1942, $26 in 1948, and $32 in 1955. Retail food prices as measured by the Bureau of Labor Statistics index advanced only 6.5 percent between 1948 and 1955. The fact that family food expenditures increased about 25 percent indicates what is sometimes referred to as "up-grading" of the diet--either use of more expensive types of foods or inclusion of more services, such as precooking of foods, in the foods purchased.

Five sets of initial reports are to be prepared and all are to be included in one Department publication series. These five are Food Consumption of Households, Dietary Levels, Home Food Preservation Practices, Home Food Production, and Home Baking Practices. Plans have been made for first releases in this series beginning late in 1956. In all reports, separate data will be shown for each region and the U.S. by income groups for rural farm, rural nonfarm, urban, nonfarm (rural nonfarm and urban), and all urbanizations combined. In the processing of these data, the work has been planned to make the listings, punch cards, and tapes as useful as possible also for later research that will require additional tabulations.

IV. MARKETING SERVICE AND EDUCATIONAL WORK

A. Foreign Marketing Services and Related Research

1. Collecting, Analyzing and Publishing World Rice Information — FAS

(a) Domestic Activities. The existing pattern of publishing informative and analytical material on production and trade in rice throughout the world has been expanded during the year. A rice marketing specialist continues to spend considerable time in foreign travel, but the increase in the flow of rice information is largely the result of the training that agricultural attaches have been undergoing.

Three new phases in connection with the release of information have been added during the past year.

(1) A quarterly detailed report on all phases of the U. S. rice industry (production, trade, prices and policy) has been distributed to Agricultural Attaches in some 55 foreign posts.

(2) A weekly summary on world prices is now prepared (FAS) and included in the Rice Market Review (AMS) issued weekly from New Orleans and San Francisco.

(3) A special news letter is now going out to members of various national committees interested in rice. This periodic release is designed to give committeemen and key leaders in the rice industry, all available background material on international developments in rice of particular significance to the U. S. A total of eight news letters have been issued since June 1, 1956.

(b) Foreign Programs. Most of the preliminary work has been completed on a project covering an international comparison of commercial rice grades. Samples will be drawn from the 1956 crop at the beginning of 1957 from principal rice exporters and will be graded under U. S. procedures to establish comparable U. S. grades. It is expected that the project will last two years and that upwards to 1,000 samples will be drawn each year.

Similarly most of the preliminary work is well underway for the comparison of both rice moving into export, as well as that produced domestically in major importing countries. This is a varietal comparison project which will run two years under which the principal and most important world varieties of rice will be analyzed and compared to the export varieties produced in the U. S. The tests will be made in the U. S. and in cooperation with the various technical services of the Department. The tests

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... Most of the preliminary work has ... project covering an international comparison of rice grades. Samples will be ... the beginning of 1957 from principal rice importers and ... graded under U. S. procedures to establish ... It is expected that the project will last two ... and that upwards of 1,000 samples will be drawn each ...

... of the preliminary work is well underway for the ... rice moving into export, as well as that ... in major importing countries. This is ... project which will run two years under ... important world varieties of rice ... to the export varieties ...

will cover a wide range of factors such as, the degree of milling, cooking tests, water soluble characteristics, amylopectin ratio, starch tests, histological characteristics, nutritional factors and others. Such tests will indicate comparability and competitiveness of U. S. rice in terms of consumer preference and acceptance. It is expected that tests may cover 60-100 major varieties of rice a year.

Projects are now underway for Japan, Thailand and several European countries in connection with PL 480, foreign currency, to determine: (1) acceptability of U. S. rice; (2) to promote the use of U. S. rice; (3) to undertake studies in potential export markets to determine suitability of U. S. grades or to develop information on what changes might be made; (4) consumer preference studies; (5) studies will be undertaken on the problems of shipment, particularly bulk consignments; and (6) market studies will be made in a number of countries to survey the competitive features as far as U. S. exports of rice are concerned. It is probable that about ten of these projects will be underway by January 1957.

Some progress has been made in cooperation with 18 other rice countries in the acceptance of basic terms in connection with rice and particularly as they relate to grading. The second international meeting was held on this subject in October 1956. It is expected that the basic terminology feature will be completed this year.

Plans for the future as applied to (a) and (b): It is planned to maximize to the extent possible the collection and dissemination of information on world production and trade.

The projects on grade and varietal comparison will be completed in two years and will be expanded as much as possible the second year.

The estimated ten projects under market development work financed by the use of foreign currencies accruing under Title I of PL 480 will run for the most part for a two-year period. Additional projects will be set up as funds may be available.

B. Domestic Market Service of USDA

1. Rice Outlook AEC-AMS

Acting on the recommendation of the Rice Research and Marketing Advisory Committee December 1955 a separate "Rice Situation" report has been authorized and the first issue is planned for release in December 1956. Heretofore, the rice report has been included as a part of the "Wheat Situation".

2. Report on Rice Market News GR-AMS

A rice market news office was opened in Cleveland, Mississippi, October 1. Cooperative Agreements and a rice market news program are in effect for the four major rice producing States (Arkansas, Louisiana, Texas and Mississippi) in the southern area. The Mississippi market news service will report soybean and oats markets as well as rice.

A leased wire system covering the four rice producing States was inaugurated about the middle of September. This system facilitates the movement of rice market news between these States as well as California.

3. Agricultural Estimates AES-AMS

In response to the recommendations of the Rice Research and Marketing Advisory Committee, in a report dated February 7, 1955, the Agricultural Estimates Division has not inaugurated a regular rice stocks reporting procedure. The Committee recommended that data on stocks of rough and milled rice by ownership, class and position, by States, at mills, including rice in transit to mills, in warehouses not attached to mills and on farms or in farm warehouses be issued at least five times a year. (August 1, October 1, January 1, April 1, and July 1.) No regular funds have been made available to inaugurate this series of reports.

At the request of the Commodity Stabilization Service, Agricultural Estimates has, however, inaugurated a series of reports covering the above items, as of August 1, 1956, October 1, 1956, January 1, 1957, and April 1, 1957. Funds to defray the cost of this work were made available to us by transfer from CSS to AMS. Special releases have been and will be made as of each of these dates. A copy of the August 1 report is attached. There is no assurance that these reports will continue after April 1, 1957.

C. Marketing Education by Cooperative Extension Service

There are no AMA rice marketing educational projects. The rice marketing educational work accomplished is what extension agronomists, marketing specialists, and consumer information specialists are able to do in addition to other programs, all of which are supported by regular Extension funds.

This work has been conducted to a limited extent on rice storage and handling problems, grading problems, and in the area of market outlook and consumer information.

This year progress was made on better organization toward the coordination and planning for more effective educational work in rice marketing. An informal memorandum of understanding on research and extension work was developed and accepted by Experiment Station and Extension Directors in Arkansas, California, Louisiana, Mississippi, Texas, and USDA Administrators of the Agricultural Research Service, Agricultural Marketing Service, and Federal Extension Service.

PROPOSALS FOR COMMITTEE CONSIDERATION

PRODUCTION

a. Rice Genetics, Breeding, and Improvement

Expand research on rice breeding to provide varieties adapted to various environmental conditions and to meet the requirements and preferences of producers, processors, millers and consumers. To meet these objectives, strengthening of the following is needed: (1) Fundamental studies on cytogenetics and genetic variation to provide the basis for improved methods of breeding new varieties, (2) the development of methods, techniques and cooperative efforts for the evaluation of breeding strains in the early generations as to their milling, cooking and processing characteristics, (3) the evaluation of rice strains and varieties from foreign and domestic sources to determine their usefulness in breeding new varieties, (4) research to find sources of resistance to rice diseases and insects, basic studies to determine factors of plant resistance to diseases and insects and development of methods to determine the reaction of varieties and breeding strains to these causal factors.

b. Physiological Studies

Expand physiological studies to determine basic factors involved in the growth and development of the rice plant. This information is necessary in order to control certain physiological disorders (diseases).

c. Weed Control

Expand work on weed control in the western rice growing area with emphasis on (1) developing herbicidal treatments suitable for controlling grass weeds in rice involving pre-planting, pre-emergence, and post-emergence applications, (2) evaluation of chemicals for selectively controlling algae and broadleaf weeds in rice, (3) develop procedures for control of weeds in rice irrigation ditches and ditchbanks, (4) studies of weed control in crops grown in rotation with rice, and (5) improvement of equipment for application of herbicides to rice fields.

d. Insect Physiology and Toxicology

Expand work on basic insect physiology and toxicology including research on the cause of insect resistance to insecticides, mode of action of insecticides, nature of and action of attractants and repellents and nutritional requirements. With the increased use of insecticides for the control of rice insects, these basic studies become necessary so that we may be prepared if rice insects develop resistance to insecticides. Basic studies on attractants, repellents and nutritional requirements might aid materially in determining the cause of resistance of rice varieties to attack by rice insects.

e. Biological Control of Insects

Expand work on biological methods for controlling insects attacking rice. This work should include investigations to determine the value of parasites, predators and insect pathogens in the control of rice insects, including stalk borers, rice water weevil, and rice stink bugs. Insect pathogens have shown promise in controlling some insects. However, because of their complex cultural and environmental requirements, additional research is necessary before widespread use of them can be recommended.

f. Soil and Water Management and Cultural Practices

Expand research on soil and water management, rotation, and cultural practices for production of rice. More information is needed in all major rice-producing areas of the United States on ways to increase the efficiency of water application and to improve the uniformity of depth of application through land forming or land leveling practices. Research on the use of irrigation on pasture establishment and management of improved pastures should be initiated in the rice producing areas. Responses of different grasses and legumes to supplemental water as affecting rapid establishment and growth needs thorough study. Critical drought periods occur frequently in the area that cause seeding failures and reduce production of both pasture and forage for hay or silage. Studies are needed to determine the most desirable soil preparation practices, and the best kinds and amounts of fertilizer including manganese and iron to apply. The effects of various cropping systems and crop sequences upon the productivity of rice lands also needs investigation.

g. Drying and Farm Storage of Rough Rice

Expand research on farm drying, storage, cooling and aerating of rough rice. The operations of farm drying and handling, associated with combine harvesting are extremely important for rice because this crop cannot be allowed to dry to a safe storage moisture before harvesting without loss of quality and, in order to minimize danger of serious field losses, should be harvested as early as possible without adversely affecting yield or quality. This research would include studies to improve cleaning equipment for wet rice and air distribution systems for most effective and economical drying in farm bins. Research on drying should be continued over a sufficient number of years to determine the effect of variations in weather conditions in the various rice producing areas from one season to another. More information is needed also on design and selection of drying equipment to be used on rice farms, including supplemental heating equipment, and on operating procedures.

These investigations would include effects of maturity, moisture content, harvesting methods and farm drying, handling and storage procedures on the prevention of deterioration such as molding, and on market qualities as determined in cooperation with marketing research agencies. (See related proposals Utilization F and Marketing B.)

h. Agricultural Aircraft Equipment

Initiate new work on the development and improvement of equipment and methods for air application of herbicides, fertilizers, and seeds as applied to rice. Weed growth in rice fields causes serious trouble to the grower as severe infestations frequently cause fields to be abandoned before harvest, and the presence of weed fragments makes the drying and storage of rice difficult and expensive. While it is now common practice to sow rice with airplanes, the need for more even distribution still exists. The application of fertilizers by air could also become more widespread with better distribution equipment.

i. Radiant Energy for Attracting, Repelling or Killing Insects

Expand research to obtain more data on the lethal effects on insects of radio-frequency energy through a wider range of frequencies. Research should be continued to determine the effects of cathode and gamma ray radiation of insect destruction as well as on the viability of the grain. Numerous adult economic insects are attracted to electric radiation chiefly in the blue end of the visible spectrum and the near-ultraviolet of the ultraviolet region. There are evidences of substantial differences in attracting insects with radiant energy by as narrow a wavelength band as 50 Angstroms. The combined efforts of engineers and entomologists are needed in detailed basic research to determine the effects of radiant energy on insects.

Exploratory work in the laboratory has also shown promising possibilities of stored-grain insect destruction by radio-frequency and also by cathode and gamma ray radiation. Adult insects have generally been destroyed more readily with radio-frequency energy and immature stages with cathode and gamma ray exposure, but all life stages have been successfully destroyed by both forms of radiation.

UTILIZATION

a. Nutritional Values and Requirements

Expand basic research on human nutrition, including nutritional values of rice products and other foods. Areas of work needing particular attention include replacement of obsolete data on carbohydrate values, determination of kind and quantity of organic acids, factors affecting amino acid requirements, role of fat and fatty acids in human nutrition, determination of human requirements for newer vitamins, physiological availability of nutrients from different foods, and effects of new methods of cooking, processing and handling on acceptability and nutritive values.

It has long been recognized that diet affects the health and vitality of people at every stage of the life cycle. We have knowledge of the importance of proteins, minerals, and vitamins, but this is only the first step in our understanding of the needs of the human body. The degree of need differs for children, youth, young adults, and older people, and with the kinds of foods and combinations in diets.

Very little is known about the functions of the various nutrients or the long-time effects of different levels of intake. Work now under way indicates that there are unfavorable interrelationships among nutrients which may cause a chain of metabolic disturbances that make for premature degenerative damage to vital organs. A current nutrition problem is how adults of this country may avoid excessive body weight and other diet-related conditions that lower efficiency and shorten life expectancy. Satisfactory solutions are unlikely until we know more about what food elements the body needs, and from what combination of sources they can best be obtained from the standpoint of nutritive content, physiological value and acceptability of foods.

b. Chemical Composition and Physical Structure of Rice

Expand research to determine the chemical and physico-chemical properties of rice constituents and the physical structure of the rice kernel as related to processing characteristics of different varieties of rice initially and subjected to various pretreatments and processing operations. This would provide basic information essential to the evaluation of rice varieties for processing and eating quality and for the development of new and improved rice processes and products. More information on both major and minor constituents, with particular reference to starches, proteins, fats, and mineral content, is the foundation for solving problems such as "heat damage", development of rancidity and off-colors, controlling bran adhesion, cracking and checking of kernels, and maintenance of enhancement of cooking, textural and nutritive qualities. Information obtained in these studies will be useful to plant breeders who seek to develop "tailor-made" strains and varieties for specific purposes, and to processors who are developing products better suited to the needs and desires of both domestic and foreign consumers.

c. Stabilizing and Improving Brown, Undermilled, and Processed Rice

Expand research to improve the stability and the textural, eating and nutritive qualities of brown, undermilled, and processed rices, with initial emphasis upon studies to alleviate the deteriorative changes occurring in the fat fractions and to overcome or prevent souring and microbial contamination. Consideration should be given to the use of coatings and impregnations which, in addition to acting as stabilizers, could also serve as carriers of vitamins, minerals, proteins and other nutrient materials, thus greatly enhancing the food value of rice and rice products.

d. New Rice Products

Expand work to develop new rice products that are attractive, easy to prepare, and designed to satisfy the taste preference, eating habits, and desires of significant groups of domestic and foreign consumers. In addition to convenience items such as breakfast cereals (cooked and dry types), new products prepared by fermentative and enzymatic processes, by malting, and by hydration-freezing-drying techniques are suggested as possibilities. New food products should be developed which utilize broken rice grains, with initial efforts directed to determining the extent of and developing methods for effectively preventing leaching losses at the broken surfaces.

e. Objective Measurement of Processing Quality

Expand studies leading to the development of new or improved methods and instruments for the objective measurement of quality factors in rough, brown, undermilled, milled, and otherwise processed rices. New or improved methods and instruments for measuring processing quality would aid materially in the selection of the raw product for processing, the development of improved processing methods and better quality control. Accuracy of quality appraisal could be improved if present subjective methods, relying heavily on sensory perception, could be replaced by objective methods. Entirely new approaches and new devices employing electronic or mechanical principles are needed in many instances. Procedures that are non-destructive, such as ultrasonic vibration and electromagnetic radiation, should be developed. Data and principles developed for objective measurement of quality should be adapted to automatic devices for sorting raw commodities and finished products according to various quality requirements.

f. Improved Processing of Rice

Expand research to increase the head yield and improve the quality of processed products by the development of new and economical methods for optimum processing of rice. Work is needed to determine the effect of maturity, harvesting procedures, temperature, humidity, air velocity and other factors affecting moisture content, chemical composition, respiration, enzymatic action, bacterial and fungal deterioration on milling quality. This information would be used as a basis for developing improved methods of processing that would produce maximum quality as economically as possible. (See related proposals Production G. and Marketing B.)

g. Food Consumption and Dietary Adequacy

Expand statistical research on food consumption and nutrient appraisal of diets of population groups to show the contribution of rice and other foods to diets and to provide a research base for food and nutrition programs. Expecially needed is information on the division of food supplies among family members, the contribution to diets of food eaten away from home, the extent to which family diets vary with the seasons, and the deductions to be made from food supply estimates for household waste, as well as extension and improvement of the tables of food composition.

Programs of the Department, as well as those of other agencies and State and local programs of nutrition education, depend on knowledge as to whether we are as a nation well fed, the groups least likely to have good diets, the nutrients most lacking in diets and the foods that provide them within current patterns of food habits. To meet these needs, up-to-date information on food consumption is required, together with the means of making dietary appraisals. A recent survey has provided new data on consumption, but little is known about household waste, variations by seasons of the year or among individuals of various ages, and the effect of these factors on dietary adequacy or market potentials. Moreover, present food composition tables, which are the basis of dietary appraisals and have other uses also, should be extended to cover new foods and additional nutrients.

h. New Uses for Rice Flour

Initiate research to develop new uses for flour from milled rice by developing processes and products that will take advantage of its unusual starch purity, whiteness, particle size, bland flavor, and physical characteristics in dispersions. Polished white rice is over 90 percent pure starch and may be ground into flour that possesses qualities that offer certain advantages for special purposes over similarly prepared flours from wheat, corn or barley. Rice flour from broken grains appears to possess economic advantages over starches prepared from wheat or corn and because of its unusual characteristics is potentially useful for new food and industrial uses.

MARKETING

a. Measurement of Market Quality

Expand studies leading to the development of new or improved methods and instruments for the objective measurement of important quality factors in raw and processed rice. New or improved methods and instruments for measuring quality would lead to materially better quality maintenance during marketing and in improvement of grade standards and maturity indices for the raw and processed product. Instrumental and chemical methods can improve quality appraisal by minimizing the element of human judgment in grading and inspection practices. Procedures that are non-destructive to the commodity should be emphasized, because these may lead to the development of automatic sorting equipment with its advantages of lower sampling and inspection costs, and more accurate separation of product according to various quality requirements.

b. Prevention of Loss and Deterioration During Commercial Storage

Expand research on off-farm drying and storage requirements for rice to prevent loss and deterioration in quality. The use of combines for harvesting rice has created a serious deterioration problem in commercial storage when marketed directly from the combine since no drying takes place in the field after harvesting. Work is needed on the effect of maturity, harvesting procedures, temperature, humidity, air velocity and other factors on moisture content, chemical composition, respiration, enzymatic action, bacterial and fungal deterioration and viability. This research in cooperation with economic and engineering work should provide a basis for developing more effective and efficient drying and storing methods to reduce deterioration and maintain quality in commercial storage. (See related proposals Production G and Utilization F.)

c. Consumers' Use and Attitudes

Expand consumer studies to ascertain the basic characteristics of the present market and possibilities for increasing consumption of rice in the United States.

It would be desirable to undertake a national cross-section study of consumers, including regional estimates, to ascertain specifically the factors associated with high consumption and with low consumption. Analysis would be made of those persons who do not eat rice at all. Particular emphasis would be placed on the reasons for such nonuse. Information would be collected on frequency of use, how rice is cooked and served, attitudes toward the product itself, cooking problems, attitudes toward food value, and price considerations.

In addition to collecting information about regular rice, certain data would be included for new and improved rice products such as precooked rice and quick-cooking rice. The results of this work would provide a basis for evaluating factors affecting rice consumption and could help direct sales and promotion programs.

e. Consumer Panel in a Large Metropolitan Area

Initiate a consumer panel in a large metropolitan area to obtain data for a continuous and comprehensive evaluation of food product advertising, promotional programs, merchandising innovations, and new product introductions on a large commercial scale. The data would yield detailed household food purchase and price records which would supplement national and regional studies of the consumption habits and attitudes toward food and nutrition in relation to family income and other characteristics. Data obtained through the panel would also provide numerous byproduct benefits in the form of comprehensive information on the trends in use of new forms of foods and food services, such as frozen and concentrated foods and food packaging.

The consumer panel would provide continuous basic market information on all principal foods, including rice in different forms, and would permit appraisal of advertising and promotion programs as in the proposal following. The cost per commodity for such appraisal would be materially reduced in a consumer panel operation through which household purchases and prices of all foods would be reported weekly.

f. Advertising and Promotional Programs

Expand research on measurement of effects of advertising and promotional programs on the retail sales of rice in additional cities. Alternative methods of evaluation would include retail store studies or a consumer panel operation as indicated in the preceding proposal.

g. Insects in Stored Rice

Expand research on developing methods to prevent insect infestation in stored rice, in relation to (1) development of protective sprays or dusts for rough rice that will not leave undesirable residues in the milled rice, (2) re-evaluation of fumigants and fumigation procedures within the limits of materials and residues currently authorized, (3) development of insect resistant packaging, and (4) increased chemical analysis services to permit residue determination for each step of the research.

MARKETING SERVICE AND EDUCATIONAL WORK

Educational Work of the Cooperative Extension Service

a. Expand Use of Rice Grades

Educational and demonstrational work on acceptance and use of rice grades for both rough and milled rice should be expanded. The work on grades should be done at all levels of marketing, beginning with producers and extending on to local buyers, millers, and wholesale distributors.

b. Drying, Storage, and Insect Control

Educational work on drying and storage practices is needed on an expanded basis to assure higher quality and better utilization of rice. Special emphasis should be placed on training dryer operators, warehousemen, and millers on technical phases of drying and storage. Attention should also be given to education on avoiding contamination and losses from insects, rodents and other causes.

c. Consumer Information

Intensify and strengthen work carried on by the Cooperative Extension Service with consumers, giving particular attention to:

(1) Disseminating research results on new product developments.

(2) Helping marketing agencies and producers learn of consumer preferences.

(3) Interpreting outlook information in terms of consumers' needs.

(4) Gearing information to meet the needs of specific groups, such as low income families.

d. Market Outlook and Development

Educational work is needed with producers, handlers, millers, and wholesale distributors on the problems and conditions affecting the market situation and outlook and prospects for future development of markets, both domestic and foreign.